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TURNBUCKLE DEVICE HAVING DIAGONALLY GUIDED WEDGE

The present invention relates to a turnbuckle device for clamping concrete shell elements, having two claws and a wedge, the claws being displaceable in a clamping direction toward one another, the wedge being guided in the turnbuckle device along a guiding direction, and the dimension of the propulsion of the wedge in the turnbuckle device determining the displacement of the claws.

A turnbuckle device according to the species is known, for example, from DE 35 45 273 A1.

Concrete shell elements are used to erect delimitations for concrete bodies to be cast, such as building walls. In order to obtain delimitations which may be cemented in, multiple concrete shell elements must typically be connected solidly to one another. Turnbuckles are used to connect the concrete shell elements.

The concrete shell elements essentially comprise a shell skin, a frame, and struts for stabilizing the frame. The turnbuckles are typically positioned in the area of the intersections of struts and frames. Each claw of a turnbuckle encloses a frame section of two concrete shell elements to be connected, and the two claws - and therefore the concrete shell elements - are clamped to one another using a wedge, i.e., the claws are moved toward one another and into one another in a clamping direction.

In the turnbuckle devices of the known related art, the direction of the translation of the wedge as it is driven into the turnbuckle device during the clamping (= wedge guiding direction) and the clamping direction have a right angle to one another. If two horizontally neighboring concrete shell elements are connected, i.e., horizontally clamped, using such a turnbuckle device, gravity acts in

its entirety on the wedge in such a way that it is drawn in the direction of stronger clamping.

In order to clamp boundary surfaces of two neighboring concrete shell elements which experience especially large forces (such as joint corners or external corners), multiple neighboring turnbuckle devices are used simultaneously. The turnbuckle devices are then typically positioned on a straight line (e.g., one below another), having parallel clamping movements of the claws and parallel movements of the wedges, which occur on one single straight line, during clamping.

The problem thus arises that the wedges of the individual turnbuckle devices may mutually obstruct one another. The turnbuckle devices must be spaced apart at least one wedge length (i.e., the extension of a wedge in the direction of the wedge guiding device when the wedge is positioned in a turnbuckle device). This limits the number of the turnbuckle devices which may be used for securing a boundary surface of two neighboring concrete shell elements.

In practice, however, an even larger spacing of the turnbuckle devices is maintained, since the wedges require movement space during the construction and disassembly of the turnbuckle devices. With spacing only in the magnitude of the wedge length, a precise construction and disassembly sequence of the turnbuckle devices must be maintained, since only the turnbuckle device located at the edge has sufficient space for moving the wedge. Furthermore, sufficient intervals of the wedge ends to any type of obstruction are also to be maintained, so that the use of tools, particularly hammers, for driving and loosening the wedges is possible.

In contrast to this, the object of the present invention is to provide a turnbuckle device in which obstruction of neighboring turnbuckle devices by their wedges may be avoided even in the event of tight spacing of the turnbuckle devices.

This object is achieved according to the present invention in that the wedge guiding direction and the clamping direction enclose an angle α less than 90°.

During clamping of two concrete shell elements, the participating turnbuckle devices span a typically linear boundary line between the concrete shell elements. The turnbuckle devices are positioned next to one another and/or one over another on a straight line running parallel to this boundary line, the clamping movements of the claws of the turnbuckle devices running parallel to one another. Because the wedge guiding direction does not run perpendicular to the clamping direction according to the present invention, the longitudinal directions of the wedges no longer all lie on a single straight line. The wedges are not advanced, in contrast to the related art, along a single straight line for all wedges, but rather each wedge is advanced on its own straight line. Movement space for the wedges is thus obtained. The spacing of the particular separate straight lines from one another is a function of the angle α and the distance of the turnbuckle devices. According to the present invention, the spacing of the particular separate straight lines is selected in such a way that it at least corresponds to a diameter of the wedge (possibly the maximum diameter of the wedge), so that the wedges may no longer come into contact.

Through the teaching according to the present invention, a larger number of turnbuckle devices may be used for clamping per length of the boundary line of neighboring concrete shell elements. In this way, connections of

concrete shell elements may be made more secure and, in particular, the maximum mechanical load which may be carried by concrete shell elements may be increased.

In the related art, the propulsion direction of the wedges to the clamped is to be oriented strictly with the force of gravity, in order to secure the wedges against unintentional loosening, as a result of shocks, for example. However, it is completely sufficient to guide a sufficient vector component of the propulsion direction parallel to gravity. Even at a deviation of 45° of the wedge propulsion direction from the gravity vector, approximately 70% of the weight of the wedge is still available for holding the clamping position, corresponding to the sine of 45°.

An embodiment of the turnbuckle device according to the present invention which is characterized in that the angle α is between 40° and 85°, particularly approximately 70°, is preferred. These angle ranges are especially suitable for wedge dimensions and concrete shell elements dimensions which are currently in use. The securing effect of gravity is also still adequate.

A refinement of this embodiment in which the angle α is approximately 45° is especially preferred. At this angle, the turnbuckle device may be used equally well for connecting both horizontally neighboring concrete shell elements and also vertically neighboring concrete shell elements, i.e., the turnbuckle may be operated equally well in the horizontal or vertical clamping direction. In this case, a position of the turnbuckle device may always be selected in which the wedge is forced into the clamping position by more than 70% of its weight.

Furthermore, an embodiment of the turnbuckle device according to the present invention in which the following relationship applies for the angle α:

$$\alpha \leq 90° - \arctan (B/L),$$

with L: length of the wedge in the wedge guiding direction and B: greatest width of the wedge measured transversely to the wedge guiding direction and in the plane of wedge guiding direction and clamping direction, is preferred. If such turnbuckle devices are positioned at an interval A, measured perpendicularly to the clamping direction and/or parallel to the boundary line of the concrete shell elements, the interval A being greater than or equal to L, mutual obstruction of the wedges, particularly touching of the wedges as the turnbuckle devices are assembled or disassembled, is precluded. A selection of the interval A greater than the wedge length L has been maintained until now in all known concrete shell elements having turnbuckle devices, and the embodiment according to the present invention may be used with all handling advantages in such existing concrete shell elements.

Furthermore, an embodiment in which the wedge is guided solely by one of the claws is preferred. The guiding of the wedge is thus simplified. The angle α may then be set very exactly.

In an advantageous embodiment of the turnbuckle device according to the present invention, the wedge has at least one depression and/or protrusion which runs diagonally to the wedge guiding direction, and at least one of the claws has a profile which engages in the depression and/or protrusion of the wedge. The profile may, for example, be implemented as a row of teeth. Turnbuckle devices profiled in this way may be designed in a broad range of transmission ratios (propulsion in relation to clamping

path); in particular, they may also be designed well for angles α less than or equal to 45°.

In another advantageous embodiment, the wedge has a cross-section which tapers along the wedge guiding direction. The wedge thus reduces its width in the propulsion direction. Turnbuckle devices which are based on the effect of the changing external dimensions of the wedge are especially mechanically simple and therefore cost-effective.

A refinement of the embodiment having the profiled turnbuckle device is advantageously designed in such a way that the wedge has a constant size, particularly a constant diameter, along the wedge guiding direction. The wedge thus maintains its width along the propulsion direction. This simplifies the guiding of the wedge in the turnbuckle device significantly, and the angle α may be set especially easily and exactly.

An embodiment in which the turnbuckle device may be positioned for mounting on internal joint corners or external joint corners or perpendicular external corners of concrete shell elements is especially preferred. Especially large forces are to be expected on the concrete shell elements at these positions, so that the clamping means to be used must be especially high-performance. Through the teaching according to the present invention, a large number of turnbuckle devices may be mounted at close intervals to one another, so that even large forces may be managed.

A concrete shell system comprising concrete shell elements and turnbuckle devices according to the present invention of the type described above is also within the scope of the present invention, the concrete shell elements each having multiple mounting positions, particularly struts, for the turnbuckle devices, the mounting positions being spaced apart from one another at an interval A in a direction

perpendicular to the clamping direction of the turnbuckle devices to be mounted on the mounting positions, characterized in that the following relationship applies for the angle α: $\alpha \leq 90° - \arcsin (B/A)$, with B: greatest width of the wedge measured transversely to the wedge guiding direction and in the plane of wedge guiding direction and clamping direction. With this geometry, the wedges may be moved independently from one another arbitrarily in or against the wedge guiding direction without the wedges being able to hit one another. The ends of the wedges are additionally well accessible to an assembler. The advantages of the present invention apply especially well if the interval A is less than or approximately equal to the length L of the wedge. In this case, the concrete shell system according to the present invention represents the single possibility for making the wedges and/or the turnbuckle devices usable and applicable in this interval. A combination of the concrete shell system according to the present invention with the embodiment of the clamping devices in which $\alpha \leq 90° - \arctan (B/L)$ is especially preferred. In this case, the lengths of the wedges also do not overlap next to one another, so that especially simple mounting of the turnbuckle devices is possible because of the free access.

In the embodiments described, the clamping direction and the wedge guiding direction typically run parallel to the planes of the shell skins of the concrete shell elements if the shell skins have a shared plane. A turnbuckle device in which the wedge guiding direction does not run parallel to the plane of the shell skins, but rather encloses an angle $\alpha' > 0°$ and preferably $0° < \alpha' < 10°$, is also considered to belong to the idea according to the present invention. This may be combined with angles $\alpha = 90°$ or even $\alpha < 90°$. The angle $\alpha' > 0°$ may also prevent collision of wedges of neighboring turnbuckle devices. However, the movement

clearance for the wedges is limited by the back of the shell skin, which faces toward the turnbuckle device.

Further advantages of the present invention result from the description and the drawing. The above-mentioned features and the features described in the following may also be used according to the present invention individually or combined in arbitrary combinations. The embodiments shown and described are not to be understood as a complete list, but rather have exemplary character for explaining the present invention.

The present invention is illustrated in the drawing and will be explained in greater detail on the basis of exemplary embodiments.

Figure 1a: shows a perpendicular external corner of two concrete shell elements having turnbuckle devices according to the related art;

Figure 1b: shows a perpendicular external corner of two concrete shell elements having turnbuckle devices according to the present invention;

Figure 2: shows an embodiment of a turnbuckle device according to the present invention having a diagonal wedge;

Figure 3a: shows an arrangement of three wedges of previously known turnbuckle devices on a straight line, the wedges running on the straight line;

Figure 3b: shows an arrangement of pivoted wedges of turnbuckle devices according to the present invention on a connecting straight line, the

wedges being pivoted in relation to the connecting straight line;

Figure 3c: shows an enlargement of the middle wedge of Figure 3 b;

Figure 3d: shows an arrangement of pivoted wedges of turnbuckle devices according to the present invention on a connecting straight line, the wedges being pivoted in relation to the connecting straight line and the lengths of the wedges next to one another overlapping;

Figure 3e: shows an enlargement of two wedges from Figure 3d.

Figure 1a shows the clamping of two concrete shell elements 1, 2, which form a perpendicular external corner, using turnbuckle devices 3, 4, 5 according to the related art.

The first concrete shell element 1 has a vertical shell skin running parallel to the plane of the drawing of Figure 1a. A boundary surface of the first concrete shell element 1 abuts the second concrete shell element 2 at a frame section 6. Only a boundary line 7 of the boundary surface is visible in Figure 1a. The second concrete shell elements 2 has a vertical shell skin running perpendicularly into the plane of the drawing. It abuts the boundary surface, and therefore the boundary line 7, with a frame section 8.

The boundary line 7 is spanned by three turnbuckle devices 3, 4, 5. The turnbuckle devices 3, 4, 5 are positioned on horizontally running struts of the concrete shell elements 1, 2. Each turnbuckle device 3, 4, 5 has a left first claw 9a, 9b, 9c, each of which engages in the frame section 6, and a right second claw 10a, 10b, 10c, which encloses the frame section 8. Using a vertically oriented wedge 11a,

11b, 11c, the claws 9a-9c, 10a-10c may be clamped in relation to one another in the horizontal direction (clamping direction). If the wedges 11a, 11b, 11c are driven downward into the associated turnbuckle devices 3, 4, 5, the concrete shell elements 1, 2 are pulled together. In order to loosen the wedges 11a, 11b, 11c, they must be moved upward.

The movement possibilities of the wedges 11a, 11b, 11c are limited in that all wedges 11a, 11b, 11c may only be moved on a single straight line. The middle wedge 11b may, for example, only be shifted by approximately a quarter of the wedge length upward or downward without hitting another wedge 11a or 11c. In particular, the wedge 11b may not be pulled out completely in order to loosen the claws 9b, 10 b from one another. The small interval to the neighboring wedges 11a, 11c in the movement direction of the wedge 11b, i.e., in the vertical wedge guiding direction here, additionally obstructs the application of a tool for clamping (advancing) or loosening the wedge 11b. In particular, a hammer, which is to drive one of the ends of the wedge 11b in or out, may not be raised. Therefore, special tools must be used in the mounting of the construction of Figure 1a, which may handle the wedges 11a, 11b, 11c in spite of the unfavorable attack angle and/or access to the wedge ends. Alternatively, the middle turnbuckle device may also be dispensed with, which reduces the carrying capacity of the clamping of the concrete shell elements 1, 2.

Figure 1b shows the same concrete shell elements 1, 2, which are now connected using three turnbuckle devices 12, 13, 14 according to the present invention.

The turnbuckle devices 12, 13, 14 each have a left first claw 15a, 15b, 15c and a right second claw 16a, 16b, 16c. The claws 15a, 15b, 15c, 16a, 16b, 16c may be displaced in

the horizontal direction toward one another in the figure (= clamping direction), in order to press the concrete shell elements 1, 2 against one another. The clamping of the claws 15a, 15b, 15c, 16a, 16b, 16c may be set in each case by a wedge 17a, 17b, 17c. The wedges 17a, 17b, 17c have a wedge guiding direction (i.e., a translational direction into the particular turnbuckle device 12, 13, 14) diagonally downward. As a wedge 17a, 17b, 17c is advanced diagonally downward, the associated claws 15a, 15b, 15c, 16a, 16b, 16c are pulled together in the horizontal direction. The clamping direction, which is horizontal here, and the wedge guiding direction thus enclose an angle α less than 90°, specifically approximately 70°. The sign of the clamping direction and the wedge guiding direction are not considered in determining the angle α, and only the smaller of the enclosed angles at an intersection of the two direction lines determined by the direction vectors is considered as the angle α.

All three wedges 17a, 17b, 17c may be moved in accordance with their wedge guiding direction without obstructions occurring due to the turnbuckle devices 12, 13, 14 neighboring the wedges 17a, 17b, 17c. The full interval A between the turnbuckle devices 12, 13, 14 is available as movement space; with greater wedge inclination or more compact first claws 15a, 15b, 15c, it would even be more. There is also sufficient space above and below the wedges 17a, 17b, 17c to be able to act with comfort on a wedge end using standard tools, such as a hammer.

Figure 2 shows an embodiment of a turnbuckle device 20 according to the present invention similar to the turnbuckle devices of Figure 1b in a vertical cross-section.

The turnbuckle device 20 comprises a left first claw 21, a right second claw 22, and a wedge 23. The two claws 21, 22

guide one another mutually in order to allow relative movement of the claws 21, 22 in the horizontal direction, specifically the clamping direction 34. The wedge 23 is guided in the second claw 22 in a wedge guiding direction 33 using two openings 24, 25. The claws 21, 22 have legs 26, 27, 28, 29 which may rest on struts of concrete shell elements and enclose or engage in frame sections of concrete shell elements.

The first claw 22 has a profiled section 30 which is implemented having a row of teeth 31. The teeth 31 are slanted by an angle ε toward the clamping direction 34. The wedge 23 has multiple grooves 32, which are also slanted by an angle ε toward the clamping direction 34. The inclination of the teeth 31 is thus tailored to the grooved profile of the wedge 23 (i.e., the relative inclination of the grooves 32 to an propulsion direction 33 of the wedge 23) and the inclination of the wedge 23 in the turnbuckle device 20 (i.e., the angle α). Furthermore, the interval of the grooves 32 is tailored to the interval of the teeth 31.

As the wedge 23 is advanced downward to the right, the edges of the grooves 32 are shifted parallel to the right at the height of the teeth 31, through which the teeth 31 are also shifted to the right. If the teeth 31 belong to the first claw 21, but the wedge 23 is guided in the second claw 22, there is a relative motion of the claws 21, 22 toward one another.

Figures 3a through 3e explain the geometric relationships on turnbuckle devices. The turnbuckle devices are each shown strongly schematically in that a projection of the particular wedge on a vertical plane is especially emphasized, while the claws are only illustrated as a dashed rectangle. The long sides of the dashed rectangle run parallel to the clamping direction, the short sides run

parallel to the direction of the boundary line of concrete shell elements to be spanned.

Figure 3a shows the limiting case of a possible arrangement of turnbuckle devices 30a, 30b, 30c having wedges 31a, 31b, 31c according to the related art in a clamped position. The wedges 31a, 31b, 31c all extend on a straight line, specifically the vertical connecting straight line of the center points 32a, 32b, 32c of the turnbuckle devices 30a, 30b, 30c. The term center point predominantly relates in this case to the center of the claw area and the center of the wedges in the clamped position shown. The positioning of the related art in this case has the problem that the wedges 31a, 31b, 31c mutually block their movement along their wedge guiding direction, which is coincident with the direction of the longitudinal extension of the wedges 31a, 31b, 31c. This is because the ends of the wedges 31a, 31b, 31c are in contact in the mounted state (or have a negligible distance in comparison to the length of the wedge). Such an arrangement may be used in principle for clamping concrete shell elements by maintaining the correct construction and disassembly sequence and/or by using special tools which do not require access to free ends of the wedges 31a, 31b, 31c for moving the wedges 31a, 31b, 31c, but this is complicated and may delay the positioning of concrete shell elements in relation to one another. This is also true for the disassembly of concrete shell elements clamped to one another.

In order to solve the problem of the wedges 31a, 31b, 31c and/or wedge ends, which stand in each others way, the teaching according to the present invention suggests that the wedges 31a, 31b, 31c and the associated wedge guiding directions be pivoted toward the clamping direction, the horizontal here. An exemplary possibility of pivoting from the perpendicular position of the wedges is shown in Figure 3a. The wedges 31a, 31b, 31c are each pivoted slightly

counterclockwise around their center points 32a, 32b, 32c as shown by the arrows 34.

Figure 3b shows the arrangement after the pivoting around the minimum advisable pivot angle. This pivoting is connected, of course, to a novel construction of the turnbuckle devices, which are now identified in Figure 3b by 35a, 35b, 35c. They are still arrayed on a vertical connection straight line, which is defined by center points 36a, 36b, 36c of the turnbuckle devices 35a, 35b, 35c, but the movement directions of the wedges 37a, 37b, 37c now run parallel next one another. The space required by each wedge 37a, 37b, 37c for movements in the wedge guiding direction overlaps neither with the required movements of another wedge 37a, 37b, 37c, nor with the location of another wedge 37a, 37b, 37c. In the clamped state of the arrangement shown in Figure 3b, the wedges 37a, 37b, 37c have punctual contact to one another at their lower left and upper right corners, and may barely slide past one another during movements in the wedge guiding direction. However, the positions of the claws 38a, 38b, 38c delimit the movements of the wedges 37a, 37b, 37c.

Figure 3c shows a detail from Figure 3b to illustrate the determination of a suitable pivot angle β for obtaining the arrangement of Figure 3b.

The wedge 37b contacts the neighboring wedge 37c at corner point E. The right edge of the wedge 37b lies in the extension of the left edge of the wedge 37c, so that the wedge 37b would just slide past wedge 37c without resistance in the event of a displacement upward to the left in the wedge guiding direction. The wedges 37a, 37b, 37c all have a width B and a length E.

A central axis 40 of the wedge 37b running in the wedge guiding direction (and the central axes of the other wedges

37a, 37c) must be pivoted by an angle β toward a vertical connecting straight line 41 of the center points of the wedges 37a, 37b, 37c. The central axis 40 runs through the center point M of the wedge 37 b and the head point K, which is in the middle of the upper short side of the wedge 37 b. The ratio of path length KE to path length KM defines the tangent of β. Therefore, β = arctan (path KE/path KM) = arctan (B/2/L/2) = arctan (B/L).
The angle β represents the completion angle of the angle α to 90°, because α runs as an angle between clamping direction (the horizontal 42 here) and the wedge guiding direction (represented by the central axis 40 here). Therefore, α = 90° - arctan (B/L).

The arrangement of Figures 3b and 3c assumes that the wedges are not to overlap along their length in the mounted state, not even next to one another. This does avoid hazard points, wear, and problems with manufacturing tolerances of the turnbuckle devices according to the present invention, but is not an absolute requirement for the invention described.

Overlapping wedges of adjoining turnbuckle devices are illustrated in Figure 3d. The turnbuckle devices 44a, 44b, 44c according to the present invention have the same width and the same mounting interval of their center points 45a, 45b, 45c and the same inclination of the wedges 46a, 46b, 46c as the arrangement of Figure 3b. Only the length of the wedges 46a, 46b, 46c is greater than in the arrangement of Figure 3b. Nonetheless, the wedges 46a, 46b, 46c have space for arbitrary movements along their wedge guiding direction, which is particularly not restricted by the neighboring wedges 46a, 46b, 46c. In this case, the wedges 46a, 46b, 46c barely slide off the neighboring wedges in the limiting case shown, which represents the largest advisable angle α according to the present invention between clamping direction and wedge guiding direction.

Actually, the space for movements of the wedges is a function of the width of the wedges 46a, 46b, 46c, the mounting interval of the turnbuckle devices according to the present invention having the diagonally guided wedges 46a, 46b, 46c therein, and the angle α.

This relationship is illustrated in Figure 3e. It shows a detail from Figure 3d and is used for illustrating the largest possible advisable angle α according to the present invention and/or the smallest possible advisable pivot angle γ in the case of wedge lengths greater than the mounting interval of the turnbuckle devices.

The turnbuckle devices 44b, 44c are arrayed on a connecting straight line 47 which is defined by the center points 45b and 45c of the wedges 46b, 46c in the clamping position or also as the center points 45b and 45c of the associated claw areas. The connecting straight line 47 intersects a boundary surface between the wedges 46b and 46c at the intersection S. The intersection S is at half the length of the connecting line of the center points 45b and 45c. The interval of the center points 45b and 45c (and therefore the interval of the turnbuckle devices 44b, 44c in the direction perpendicular to the clamping direction and/or in the direction parallel to the boundary line of the concrete shell elements to be connected) is A. The width of the wedges 46b, 46c measured perpendicularly to the wedge guiding direction is B. The wedge 46b has a central axis 48 which runs along the wedge guiding direction at half the width of the wedge 46b. An auxiliary line 49 runs perpendicularly to the central axis 48 and intersects the intersection S. The intersection of the auxiliary line 49 with the central axis 48 is identified as the internal point I of the wedge 46b.

The triangle MIS is observed to determine the pivot angle γ between the central axis 48 and the connecting straight

line 47. M corresponds to 45b. The ratio of the lengths of the paths IS to SM defines the sine of γ. Therefore:
γ = arcsin (path IS/path SM) = arcsin (B/2/A/2) = arcsin (B/A). The angle is the completion angle of the angle α to 90°, so that $\alpha = 90° - \arcsin (B/A)$.

It may be seen that in the frequently occurring case of small widths B compared to the interval A, the following applies as an approximation:
path length IM = path length SM. Observing this boundary condition, the sine may be approximated by the tangent.

In the case of conical wedges, the advantages of the present invention may be achieved in any case if the largest occurring width on the wedge is used as the width of the wedge as defined in the above observations. In specific cases, however, an averaged width may also be used.

Turnbuckle devices positioned arrayed along a straight line are used for clamping concrete shell elements, these turnbuckle devices having wedges for setting the clamping using the wedge propulsion. The wedges according to the present invention are positioned inclined toward this straight line in order to avoid collisions of wedges of neighboring turnbuckle devices as the wedges are advanced or driven out. Blocking of the access to the wedge ends by neighboring wedges is also prevented.